§12. Intensity/Phase Measurement for mm-Wave Using Network Analyzer

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In order to design the mm-wave components, a characteristic of wave propagation has been investigated, based on intensity measurements. Gaussian beams are used in quasi-optical transmission. In this case, beam parameters, which are waist points and radii, in two coordinates may describe the propagation characteristic. In application of the components to the high power transmission lines, there are arcing problems in waveguides and the components. The generation of pure Gaussian beams is a key to avoid the arcing. A flat Gaussian beam, whose peaking factor is smaller, is desirable to reduce the heat load density at windows of gyrotron and transmission line. Then, not only intensity but also phase information of the propagating wave are required in formation of the desired beams. Measurement system to take the intensity and phase information is shown in Fig.1. A network analyzer detects the intensity and phase from IF (Intermediate Frequency) signal at a harmonic mixer. There is a phase lock loop between a RF source and the network analyzer. The network analyzer communicates with a LO (Local Oscillator) synthesizer, and the accuracy of the frequency is determined by the synthesizer. Here, the IF frequency is 20MHz. A UNIX workstation controls the instruments and takes data. For instance, the measured intensity and phase profiles are shown in Fig.2. The beam is radiated from the Gaussian beam generater that is composed of a scalar horn antenna and a quasi-optical mirror. The intensity profiles are normalized by the maximum , and the phase is counted from the beam center where is the maximum of the intensity. The intensity profiles fitted as Gaussian with the beam spot sizes, ω_x and ω_y, are also shown in the figure. Here, the spot size are described as

$$\omega_\sigma(z) = \omega_{0\sigma}(1 + [\frac{\lambda(z - z_\sigma)}{\pi\omega_{0\sigma}^2}]^2)^{1/2}; \quad \sigma = \mathrm{x\ or\ y},$$

where z is the coordinate along the propagating axis, λ is a wavelength, $\omega_{0\sigma}$ is a waist radius, and z_σ is a waist point in the z-coordinate. At $z = const.$, the phase surfaces are parabolic with the radii of the wave-front curvature, R_x and R_y. Here, the radii of the wave-front curvature are

$$R_\sigma(z) = z(1 + [\frac{\pi\omega_{0\sigma}^2}{\lambda(z - z_\sigma)}]^2); \quad \sigma = \mathrm{x\ or\ y}.$$

The waist points and radii, z_σ and $\omega_{0\sigma}$, can be deduced from the fitted ω_σ and R_σ. The values are consistent with the results obtained from intensity dependence on the position of z.

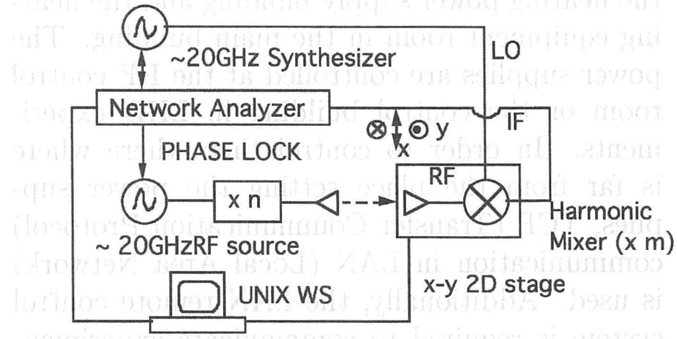

Figure 1. Measurement system to detect wave intensity and phase.

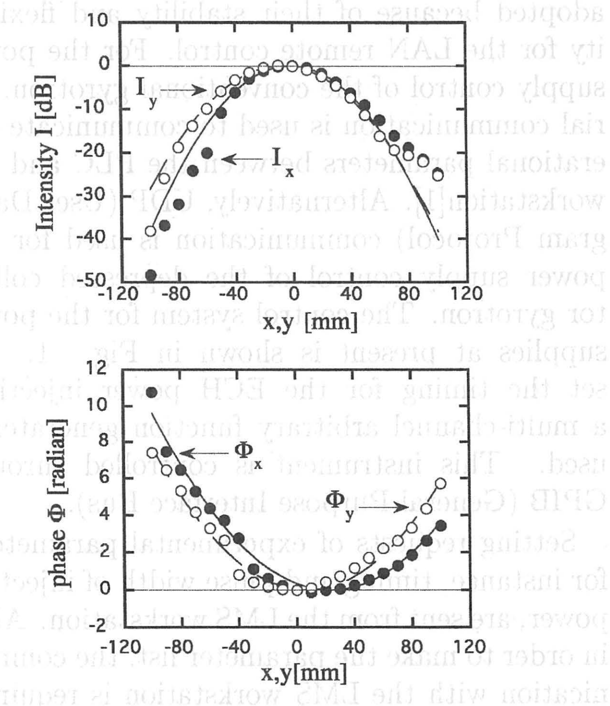

Figure 2. Measured intensity and phase profiles. The curves fitted as Gauss and parabolic functions are also shown.